ISSN:0975-1459
Journal of Pharmaceutical Sciences and Research
www.jpsr.pharmainfo.in

Dependence of Sports Results on the Plasticity of the Central Nervous System and Brain Asymmetry

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Abstract

The paper presents data on the physiological asymmetry of the brain. Some authors note that one should take into account the features of functional interhemispheric asymmetry when constructing a training process for improving sports results. Many authors confirm that regular training in sports leads to improvement in plasticity and the development of functional connections between brain regions. E.B. Sologub notes that among qualified right-handed athletes symmetric zones of subdominant hemisphere form a functional reserve, while the “working systems” are localized in the left dominant hemisphere [1]. All psychophysiological indicators of training activity are expressed in the bioelectrical activity of the brain and should be taken into account in the justification of various technologies of sports training of single combat athletes [2, 3].

Keywords: functional asymmetry of the brain, neuromuscular apparatus, functional-motor system, interhemispheric relationships.

INTRODUCTION

Leading experts in the field of theory and methodology of sports training have the opinion that preparation of single combat athletes at the stage of sport improvement should be predominantly individual, especially at the stage of higher sportsmanship [4-8]. Model standards, including not only particular features of preparedness generally accepted in the sports theory but also the idea of the profile of lateral brain organization optimal for the particular kind of sport activity, can serve as orientation for purposeful individualization. According to F.M. Gasimov, this will allow to take into account individual disagreements with model characteristics, i.e. those individual traits that are the key to success in the sport of higher achievements [9].

V.M. Krol argues that the criteria for reliability and energy efficiency should be the basis for choosing a rational structure of the movement [10]. The reliability of motor actions is determined by morphogenetic features of the organism ensuring their stability, and depends on the presence of the necessary level of asymmetry in the course of movement.

According to many scientists, asymmetry of movements makes it possible to reduce their uncertainty and increase their stability due to the possibility of choosing an optimal variant of the structure of motion, because the organism in the course of evolution has formed the mechanisms of the nervous system that ensure the choice. These include the fundamental laws of the human brain - interhemispheric asymmetry and interhemispheric interaction, which are largely due to genetic mechanisms and, at the same time, are influenced by social, professional, and especially sports training [11-14].

Achievement of mastery in sports, according to V.I. Lyakh, is, first of all, the art of the movement [15]. According to this, the applied and the most important theoretical problem of sports physiology is to uncover patterns of individual development of the neuromuscular system and the function of the propulsion system of organisms. According to N.A. Litvinova, the latter is confirmed by the reasoned substantiation of the presence of an individual neurodynamic, psychophysiological profile that correlates with the type of functional profile of the lateral organization of the brain [16]. It is important to note that the individual profile of asymmetry or the profile of the lateral organization of the brain, according to D.G. Tolasova, can be considered as a factor determining the specificity of the motor functions of the athlete, which determines the distribution of the dominance of brain activity in the organization of motor and sensory functions [17]. Thus, in the work of S.V. Nikolskaya it is figured out that among single combat fencers with foils of the largest international competitions, the number of left-handers is 10 times higher than that among the population. Left-handed fencers of high class, in comparison to right-handed ones, have shorter latent time, ensuring the success of simple and quick actions, but less speed of processing complex information. This complicates the use of technical and tactical actions of high complexity, as well as the adoption of extraordinary solutions in conditions of shortage of time. Left-handed fencers prefer simpler technical and tactical high-speed actions. For them, the attacking style is adequate, for right-handed people it is counterattacking one [18].

Relevance

Evaluation of the functional state of the central nervous system is one of the most actual problems of the training and management of the training process of single combat athletes.

Many scientists note the significant role of indicators of functional and sensory asymmetry in improving sports performance [14, 19-23].

Functional asymmetry reflects the state of subordination readiness, which provides coordination adjustment of motor actions [12].

At the present time, hemispheric interaction is actively studied in the analysis of mechanisms of human adaptation to environmental factors, since dynamic rearrangements of interhemispheric asymmetry contribute to the plasticity of adaptation of men to extreme conditions [24, 25].

Functional asymmetry of the brain is psycho-physiological prerequisite, which determines various aspects of sports activity, and allows to identify the prerequisites and features of motor development, mental and physical state of athletes, and individualize the process of athletes training [21, 26].

D.A. Tolasova also notes the possibility of constructing an educational process taking into account individual and typological features of functional interhemispheric asymmetry, considering this factor significant for the success of sports activities [9].

In the work of V.P. Leutin and E.I. Nikolaev the great biological significance of the functional asymmetry of the brain was noted. It means that functional asymmetry has a great regulatory role [12]. Functional asymmetry reflects the state of subordination preparedness, which provides coordination adjustment of motor actions. Kolyshkin V.V. shows that distribution of functions between the hemispheres forms a mobile and flexible profile of interhemispheric asymmetry of the brain that determines the range of adaptive functions of interhemispheric relations and dynamics of the basic nervous, humoral and immune processes on which the success of adaptation to sports activity depends [27].

DISCUSSION

The dependence of the performance of competing bimanual movements on the type of the profile of sensorimotor asymmetry (according to the preference of the hand, eye and ear) and the nature of the manual profile is shown in the study of Yu.V. Malovoy [28]. The best results are noted in case of the mixed type of asymmetry. “Pure righties” have worse results especially for the left hand. The variant of the right hemisphere domination is optimal for bimanual actions with spatial afferentation by sight.

The study of the profile of functional interhemispheric asymmetry as a factor that determines the success of various aspects of the training and competitive activity of single combat athletes seems to be quite promising in the context of sports psychophysiology, and is crucial for identifying scientifically grounded prerequisites that determine the mental and physical condition of athletes, as well as the conditions for their motor development.

E.V. Bochantseva in her work points out that one of the most effective tools for noninvasive analysis of brain activity and functional interhemispheric asymmetry is the electroencephalographic method of recording and analyzing biopotentials in dynamics depending on the surface of the cerebral cortex [19].

Many researchers state that the rhythms of the electroencephalogram (EEG) have a different origin and functional significance. EEG reflects the total activity of a large number of brain cells and consists of many components. Analysis of the EEG makes it possible to identify waves that are different in form, constancy, periods of oscillation and amplitude (voltage). In a healthy person, an EEG has typical features: rhythmic activity with the frequency of about 10 Hz and an amplitude of 50-100 μV is assigned to the alpha rhythm from all regions of the cerebral cortex. Other rhythms are also recorded on the EEG: the lower ones are delta and theta (2-4, 5-7 Hz), and the higher ones are beta rhythms (13-30 per second), but their amplitude is not high, and they overlap with alpha-vibrations [1, 29].

P. Nunez, B. Wingeier and R. Silberstein in their work note that the rhythmic nature of brain biocurrents is associated with individual features of self-regulation mechanisms and the level of plasticity of neurodynamic processes. Thus, the ratio of the EEG rhythms changes with the change in the functional state. For example, when you go to sleep, slow oscillations become dominant, and the alpha rhythm disappears. With the strong excitation against the background of alpha rhythm disturbance, sharp changes are revealed: they manifest themselves in the intensification of slow oscillations, sometimes of beta rhythms, violation of regularity and frequency of alpha rhythm. These and other changes have nonspecific character [30].

According to S.I. Soroko, with pronounced alpha activity, delta and theta rhythms in a healthy adult are virtually unnoticeable, as they overlap, having a more pronounced amplitude by an alpha rhythm [31].

Thus, in the work of E.V. Fomina there is an inversion of hemispheric dominance with a favorable course of adaptation to training and exercise in sports activities [20].

According to the work of some researchers, three types of people can be distinguished, differing in their level of adaptability. In persons with a low level of adaptability, low-amplitude, flat EEG is recorded, while in persons with a high level of adaptability in the EEG an alpha rhythm dominates. And in women we can see higher frequency of alpha rhythm and more beta activity, which correlates with gender differences in individual characteristics, i.e. a higher level of adaptability in women, which appears to be genetic conditionality and may be associated with hormonal characteristics of the female body [1, 19, 31].

T.V. Popova notes the real opportunity to analyze the central mechanisms of functional interactions that are formed at the system level in the training and competitive activity of athletes. Experimental neurophysiological studies of vibrational bioelectric processes of projection and associative zones and their space-time relations in humans during the execution of arbitrary movements are given [32].

Reflection of the most optimal state of cortical-subcortical relationships that provide the background, the basic state for the intellect and the normal emotional life of a person, and the intensity of the flow of information from the outside and regulating the level of wakefulness are reflected in the alpha range [19]. The alpha rhythm of the EEG changes in response to various types of mnestic and cognitive activities, reactions to states of relaxation, meditation, multidirectional shifts in emotions [19]. The growth of the amplitude of the alpha rhythm, according to Bachantsev, EV, is characterized by the state of relaxation, and the alpha activity of the right hemisphere reflects the integral activity of the inhibitory processes of the central nervous system [19].

E.V. Fomina in her study revealed that the influence of specific physical load is manifested in significant changes in the spatial organization of the bioelectrical activity of the sports swimmers' cerebral cortex. The dynamics of the rhythms of the low-frequency ranges of the left hemisphere can be considered as an indicator of reduced activation, since the increase in slow-wave activity is considered by most researchers to be the most characteristic sign of a decrease in the functional state [20]. In addition, this author points to the specific impact of physical exertion on highly skilled athletes, which leads to the activation of theta rhythm power that W. Heller and J. Nitchke associate with positive emotional experiences and the emergence of the state of stable internal concentration that helps to successfully solve the motor tasks of increased complexity [20, 33]. At the same time, in athletes of high qualification, in comparison with less trained athletes, the power of the alpha band was reduced in the temporomandibular and central leads of the right hemisphere of the brain. According to the studies of W. Heller and J. Nitchke, the right parietal-temporal region is involved in the modulation of vegetative and behavioral activation. The activity of this zone is associated with the intensity of psychoemotional stress, which is caused by the developed connections of this region with the structures of the intermediate brain. Therefore, the smaller power of the alpha range in the most successful athletes indicates the features of vegetative maintenance of emotional states, which can manifest itself in psychoemotional resistance to stressful situations of sport rivalry [33].

Psychophysiological predictors of the success in competitive activity are low power indicators of rhythms of slow wave ranges, which are combined with a strong, mobile and labile nervous system, as well as a preference for goals of high subjective value. A decrease in the activation of the temporal parietal region, which is reflected in the peculiarities of emotional experiences of highly skilled athletes, can be considered as one of the success predictors [20].

One of the essential criteria for diagnosing psychophysiological determinants of the successful training and competitive activity of single combat athletes is the normal EEG, which is characterized by symmetry in the cortex of the cerebral hemispheres, although not completely absolute [1, 29, 31].

Koryukalov Yu.I. in his study analyzed the background bioelectric activity of the brain in athletes and untrained people. Thus, in almost all athletes alpha activity was revealed on EEG in the background record, in contrast to the untrained group of subjects, in whom it was detected only in 1/3 of the cases. The predominant frequency in both groups was 10-10.5 Hz, but the athletes had a peak at 7-8 Hz. The author related this to a more developed ability for self-regulation. Also, athletes showed dominance of alpha activity both in the occipital and in the fronto-central divisions [29].

It should be noted that in most athletes compared to untrained people, the alpha rhythm power was more pronounced in the frontal leads than in the central ones, which underlines the possibility of their arbitrary control by their functional state [32].

When the load is localized, alpha and beta rhythms undergo the initial changes with the development of their synchronization in the fronto-central leads in athletes and the central-occipital ones in untrained people, and the change in the power of the theta rhythm spectrum occurs later. Consequently, as indicated by Yu.I. Koryukalov, synchronization of different parts of the cortex of the cerebral hemispheres into a single neural network with functional load makes it possible to form the necessary working state, and regular "training" of synchronization of brain biocurrents develops more stable connections between its departments. As a result, an integrated interaction of cortical and subcortical structures is formed for the rapid mobilization of resources in the performance of the specific technical and tactical action [29].

Studies by C. Lebel, L. Walker and A. Leemans confirm that regular sports training leads to improved plasticity and the development of functional connections between the brain regions [34].

Interesting data have been received by Efimova I.V., who shows that under functional loads the dynamic indices of functional brain asymmetries depend on the initial state of the subjects, on the kind of load, and specialization of the cerebral hemispheres. The change in the sign of interhemispheric difference occurs with greater probability when the load increases. Thus, the number of subjects with zero interhemispheric difference is reduced under the influence of physical exertion [14].

E.A. Kostandov believes that functional asymmetry can be amplified, reduced, or altered during the learning process. The right hemisphere is less susceptible to corrective influences of stimuli; it is more autonomous than the left one [35].

E.B. Sologub notes in his works that in the most qualified right-handed sportsmen, the symmetric zones of the subdominant hemisphere form a functional reserve, and the "working systems" are localized in the left dominant hemisphere. Asymmetric training leads to the creation of asymmetric functional systems in the apparatus of central control, which affects the nature of the electrical activity of the cortex [1].

Thus, psychophysiological determinants of training and competitive activity of athletes are reflected in the bioelectrical activity of the brain and, therefore, they should be taken into account in the scientific justification of the technology of sports training of single combat athletes.

CONCLUSION

1. Evaluation of the functional state of the central nervous system is one of the main tasks in the management of the training process.
2. Dynamic indices of functional brain asymmetries depend on the initial state, type of load, and specialization of the cerebral hemispheres.
3. When the functional state of the central nervous system and the level of plasticity of the neurodynamic processes change, we can see change in the state of the EEG rhythm.

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